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EARLY THERMONUCLEAR WEAPONS DEVELOPMENT: THE ORIGINS OF THE HYDROGEN BOMB (U)

CRITICAL NUCLEAR WEAPON DESIGN INFORMATION
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May 1969

ABSTRACT (CFRD)

This paper broadly describes the origins and development of early thermonuclear weapons. The period covered extends from the introduction of the concept of a terrestrial thermonuclear reaction in 1928 to normal stockpiling of combat-ready thermonuclear weapons in 1955.

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FOREWORD

This document is a record of the early thermonuclear weapons development program and was compiled by the author following an interview with Dr. Carson Mark, T Division Leader, Los Alamos Scientific Laboratory. The appointment was arranged by Dr. Leslie M. Redman, D-6 Group Leader. The information provided by Dr. Mark is presented herein as a permanent record of the inception and design of very early thermonuclear weapons. An earlier draft of this document was read and accordingly amended by Dr. Redman, Dr. Mark, and R. Krohn of Los Alamos Scientific Laboratory.

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EARLY THERMONUCLEAR WEAPONS DEVELOPMENT: THE ORIGINS OF THE HYDROGEN BOMB

The possibility of producing a terrestrial thermonuclear reaction had been discussed ever since a proposal made in 1928 by Atkinson and Houtermans in Zeitschrift für Physik (v. 54, p. 656) suggested that the source of stellar energy was thermonuclear in nature. At the time, however, the concept of a terrestrial thermonuclear reaction was strictly theoretical because there was no device available, or even conceivable, that would have enough energy to begin the reaction.[1]

One of the early steps away from the theoretical and towards the real development of a terrestrial thermonuclear reaction was taken in May 1942 when Arthur H. Compton requested Robert Oppenheimer to compile data covering the basic nuclear reactions produced by fast neutrons. Oppenheimer subsequently assembled a group of theoreticians at the University of California at Berkeley. This group, including Edward Teller who was to play a decisive role later in the development of the thermonuclear bomb, came to a somewhat pessimistic conclusion: it was felt that the amount of nuclear material needed for a weapon might be prohibitively large. However, this discouraging proposition was more than balanced by a startling possibility.

The discussions and calculations suggested that a reaction more powerful than nuclear fission might be generated by thermonuclear fusion of deuterium, the heavy-hydrogen isotope. This possibility was of such immediate concern that in July 1942 Oppenheimer visited Compton's summer retreat in Michigan to communicate the news, which soon spread among scientists at Berkeley and Chicago, despite conscientious efforts to suppress references to a high-yield weapon that might use a more easily acquired material than uranium-235 or plutonium-239. Oppenheimer consequently arranged for basic nuclear studies of the light elements, using cyclotrons at Harvard and Minnesota Universities, and interest was aroused in the construction of a heavy-water plant.

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In 1944, after Edward Teller entered into association with the F (for Enrico Fermi) Division at the Los Alamos Laboratory, an investigation was started on problems relating to Super, as the earliest thermonuclear design was called.[2] Concurrently, as the atomic bomb became more and more of a reality, the prediction of temperatures in the order of kilovolts* which would be created in the detonation suggested that such a bomb might serve as a device to start a thermonuclear reaction.[1]

It was also determined that the most easily initiated thermonuclear reactions would involve isotopes of the first element, hydrogen, because the potential barrier between two nuclei is determined by the product of the nuclear charges, and hydrogen has a nuclear charge of one.

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Three isotopes of the lightest material, hydrogen, are known: protium or ordinary hydrogen, the nucleus of which is one proton; deuterium, the nucleus of which is one proton and one neutron; and tritium, the nucleus of which is one proton and two neutrons. Research showed that two protium nuclei do not fuse at all readily. However, the following reactions are possible:

$$D + D \rightarrow {}^{3}He + n + 3.2\ MeV$$

$$D + D \rightarrow T + p + 4.0\ MeV$$

$$D + T \rightarrow {}^{4}He + n + 17.6\ MeV$$

The first two reactions have about equal chances of occurring.

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A cryogenic (low temperature) laboratory with facilities for the production of liquid hydrogen was included in the original construction of Los Alamos with the thought that deuterium might be used in experiments relating to Super. The production of a few cubic centimeters of tritium by irradiation of lithium was undertaken by the Clinton Laboratories at Oak Ridge at the request of Los Alamos, and samples began to arrive on the Hill, as Los Alamos came to be known, early in the spring of 1945.

It was theorized that the energy of an exploding atomic (fission) bomb could be used to heat deuterium or a mixture of deuterium and tritium to the point where fusion between the hydrogen isotopes would take place.

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It was therefore concluded that development of a suitable energy transfer method would require so much time and effort that the hydrogen weapon should not be considered for wartime use. Priority was thus given to the fission bomb, as it represented the only real possibility for shortening the war. However, thermonuclear calculations were continued, and a fairly complete theory of Super operation (as then conceived) was prepared.[4] Early computations were made on an Eniac computer at Aberdeen, Maryland, but the assumptions made in setting up the model to be calculated were too limiting, and the results were inconclusive.[2]

The end of World War II brought a scientific exodus from Los Alamos and temporary cessation of work on Super.[2] Later, however, interest in a terrestrial thermonuclear reaction was revived in a conference held at the Hill on April 18-20, 1946.

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Carson Mark and Robert Richtmyer felt that fundamental study was required of the processes that occurred during the detonation of a nuclear device and pursued this work at Los Alamos during the summer of 1946. Teller proposed an alternative Super design called Alarm Clock, so-named because it was hoped that it would awaken people to the prospects of thermonuclear weapons.[2] (The post-war period was one of public apathy to the need for atomic weapons.)

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The Board felt that there were many experimental questions yet to be answered, but that it might be possible to create a bomb two or three times as powerful as the wartime Fat Man. When it was pointed out that there would no longer be a critical mass limitation on the size of the bomb, some meeting attendees feared that a large bomb might poison the entire atmosphere with fission products.[7]

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By the summer of 1947, three possibilities for using fusion energy in nuclear bombs had been proposed and theoretically explored: Super, Alarm Clock, and most recently, Booster.

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Little immediate action was undertaken on Booster, as the neutronic properties of an exploding uranium assembly posed a problem too difficult to handle with

*In common with all other Super concepts, this design required a fission bomb to start the process.[6]

available techniques, experience, and equipment. A calculation was set up describing the burning of deuterium and was placed on the shelf to await availability of the Maniac computer. *

Starting early in 1948, efforts were made to secure realistic calculations of an unboosted hydride device, using Monte Carlo methods on the Eniac computer. A hydride model was planned for test in Operation Greenhouse, and many calculations were made to establish a favorable design and to estimate the model's performance. In principle, the hydride appeared to produce an explosion using a smaller amount of active material than that which would detonate if used in the form of pure uranium or plutonium. [redacted]

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Such was the status of hydrogen bomb work when President Truman was informed on September 21, 1949, that an atomic explosion had taken place in Siberia sometime between August 26 and 29. The Joint Congressional Committee on Atomic Energy was notified, and a meeting was held with the Joint Chiefs of Staff on October 14, 1949, to re-evaluate existing nuclear projects in light of the Russian event.

In this meeting, the Chief of Staff for Air made a strong plea for the development of thermonuclear weapons, but the other Chiefs of Staff were noncommittal. In contrast, the Congressmen felt that thermonuclear weaponry should be advanced as rapidly as possible and urged the United States Atomic Energy Commission to authorize a hydrogen bomb program that would be as bold and urgent as the wartime nuclear program.

The General Advisory Committee of the AEC met October 28-30, 1949. The majority of the members voted against prosecution of the thermonuclear project and concluded that if the United States refrained from developing a hydrogen bomb, the Russians would not then undertake a similar program of their own. The committee reports, both majority and minority, were forwarded to the President of

*The calculation was subsequently made in 1953-1954 and showed that the experiment would not have succeeded in its proposed form. [2]

presented difficulties. Probably Los Alamos scientists were never less sure of thermonuclear feasibility than early in 1950. However, work continued and some experiments were planned for Greenhouse. Later in the year a serious program setback occurred when on June 25, 1950, the United States declared its intent to help defend South Korea, and development and production of small fission weapons for possible use in this conflict became of interest.[9]

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the United States on November 9, 1949, by the Atomic Energy Commission. Two AEC commissioners favored an immediate thermonuclear program; the other three sided with the General Advisory Committee.

On November 18, 1949, President Truman appointed a special committee of the National Security Council to assist him in reaching a decision. This group of three members reported January 31, 1950. Dean Acheson, the Secretary of State, and Louis Johnson, the Secretary of Defense, recommended that steps be taken to determine the feasibility of a hydrogen bomb. David Lilienthal, Chairman of the AEC, expressed disapproval. However, that afternoon President Truman issued the following statement: "It is part of my responsibility as Commander in Chief of the Armed Forces to see to it that our country is able to defend itself against any possible aggressor. Accordingly, I have directed the AEC to continue its work on all forms of atomic weapons, including the so-called hydrogen or Super bomb."[9]

The news that the General Advisory Committee and the majority of the AEC commissioners had voted against developing a thermonuclear bomb created disapproval among some of the atomic scientists. They felt that the AEC sanctioned minor improvements to atomic weapons but declared it immoral to advance in the thermonuclear field.[9] This reaction among the scientists prompted several to commit themselves to work on the new device.

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Prospects for achieving a hydrogen bomb actually deteriorated in the three months between October 29, 1949, and January 31, 1950. Lack of a computer to perform the required calculations, questions concerning a technique to initiate and complete a fusion reaction, and problems of providing a deliverable weapon all

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[redacted] This was a revolutionary concept and was discussed June 16 and 17, 1951, in a conclave of scientists and high government officials assembled at the Institute for Advanced Study, Princeton, New Jersey, then headed by Oppenheimer. There was unanimous agreement that the Los Alamos Scientific Laboratory should proceed as quickly as possible with its thermonuclear program adjusted to this new state of knowledge.[9]

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Project Matterhorn was established to help in the work. Informal agreements were reached between Los Alamos and Princeton University and work started May 25, 1951, in the newly acquired James Forrestal Research Center near the University campus.

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Marshall Holloway was selected to head the thermonuclear work at Los Alamos. He was a logical choice, but Teller disagreed and left the project. Teller subsequently talked to the General Advisory Committee of the Atomic Energy Commission in mid-December concerning the need for a new weapons laboratory. The idea was not favored, since it was felt that a new laboratory would lower the morale of scientists on the Hill and lure people away from Los Alamos.[14]

Teller next approached the University of Chicago and tried, unsuccessfully, to interest them in starting a new laboratory. He then sounded out the Air Force, and received a more favorable reaction. Subsequently, Ernest O. Lawrence of the University of California offered to head up an organization, and a new branch of the Radiation Laboratory was established at Livermore, California, July, 1952.

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Later reports that this branch contributed much to the early thermonuclear program were described by Teller as grossly and embarrassingly exaggerated.[9] In fact, no really worthwhile ideas were produced by this laboratory until 1955.[14]

By early 1952 the log jam in computing resources was rapidly breaking. The Institute for Advanced Study released the design of John von Neumann's recently completed Maniac, and two of these machines were built. One was installed at the Institute and the other at Los Alamos. The equipment made possible much more exact and far more extensive nuclear calculations than had previously been possible.

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Subsequently, in 1952, there was a period of time when the Maniac, a Univac in Philadelphia, and the SEAC in Washington were all engaged essentially full time on Los Alamos and Matterhorn thermonuclear calculations. Calculations were now so extensive, for example, that in the course of running a Super problem on the Maniac, the number of basic arithmetical calculations performed was of the same order of magnitude as the total number of similar operations performed at Los Alamos, excluding those done on the Los Alamos Maniac, from its beginning in 1943 to that date.[5]

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Impetus to the program came early in August 1953, when Moscow announced that the Soviets had broken the American thermonuclear monopoly. A few days later, August 12, 1953, the Kremlin was more specific and boasted a successful thermonuclear test. The Russian claim was confirmed by the Atomic Energy Commission.

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On August 31, 1954, the Military Liaison Committee informed the Military that the TX-15 would enter stockpile in March 1955. This latter date marked the start of normal stockpiling of combat-ready thermonuclear weapons.

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